developmental relations of the simple vertebrate eye and the compound eye, etc., etc., the reader is referred to the full treatment and the cuts of the original. E. C. S.

Psychophysische Untersuchungen. Dr. F. C. MÜLLER-LYER. DuBois-Reymond's Archiv. Supplement Band. 1889. pp. 91–141.

This very extensive research is so intimately connected with the many explanatory tables and illustrations, that a resumé of its contents must be confined to a statement of the most general points; special students of psychophysics must go to the article itself for the detailed numerical results and their justification. The article begins by maintaining that it is wrong to speak of *the* psychophysic law, for there may be any number of such laws; the problem is to determine all the conditions that affect sensibility to differences of stimuli, and the intensity is but one of such conditions. There will be here considered the relation of the intensity and the extension of optical stimuli to the sensibility. The author had shown that Weber's law does not hold for sensations of brightness (method of detecting the difference between two differently illuminated discs), but as the stimuli increase, the sensibility increases, though at a constantly decreasing rate. This was tested separately for each eye, with a light disc upon a darker ground or vice versa, for a great range of intensities, etc. This may also be expressed by regarding the effect of the application of the stimulus to be the lowering of the irritability, but not as rapidly as the stimulus increases. It is concluded that for visual sensations, as the stimulus doubles its value, the irritability decreases by one-third its value. Some of these points were specially tested for peripheral regions of the eye, and it was found that such portions are in general more sensitive to the vision of small dots than the fovea, and also that Weber's law seems to hold better for the peripheral than for the foveal portions. Had the sensibility been independent of the intensity of the stimulus, the determination of the relation of sensibility to the extension of the stimulus would be easy; but as it is, we are dealing with two variables at a time, and have the complex problem of determining how the sensibility changes for each intensity when the extension remains constant, and how it changes for each extension when the intensity remains constant. This the author does for visual sensations, expressing the result by a surface in the three dimensions of space. For changes in extension, the general result is that as the surface upon which the judgment of difference of illumination is founded is increased, the sensibility increases, at first relatively rapidly, and then more and more slowly. These relations are subjected to a minute experimentation, the result of which is a series of tables expressing the influence of the changes in any one of the factors of the stimulus upon the rest. The main point is the treatment of the sensibility, not as dependent upon a single variable, but upon several. The article certainly merits detailed study, but the question arises whether these exact and many-sided calculations are warranted by the accuracy of the method, and whether we should not demand a corroboration of these results by other methods before drawing the sweeping generalizations here propounded. J. J.

Neue Grundlegung der Psychophysik. HUGO MÜNSTERBERG. Beiträge zur experimentellen Psychologie. Heft, 3. Freiburg, 1890. pp. 122.

It is impossible to notice this original and painstaking contribution to Psycophysics without renewing the protest against the undue length to which all the studies of this series have been drawn. It is not sufficient that the spirit of science should enter into the methods of the new Psychology; it must also enter into its exposition, and we feel assured that the author is very considerably diminishing the influence of his

work by his undue prolixity. The three instalments of Dr. Münsterberg's work could easily have been printed in a pamphlet the size of the smallest of them, without omitting anything essential or important. If this disastrous policy is to be continued, let us at least be supplied with an index of principal points, so that those who want merely the kernel of the work may know where to find it.

The cardinal thought of this research is, that we cannot measure sensation-intensities in the ordinary sense, because only that which can be reduced to units can be measured. A weaker sensation is not contained in a stronger as an inch is contained in a foot or an ounce in a pound; but each intensity of the stimulus gives rise to a sensation qualitatively different from any other sensation. All quantitative differences of sensation are thus resolved into qualitative differences—of a special kind, however, namely, such as depend upon differences of muscular tension. It is held that our organism reacts to every stimulus by reflex muscular innervations which give rise to feelings of tension (*Spannungsempfindungen*), and it is the perception of differences of degree of these feelings that lies at the basis of intensity distinctions. All physical measurements ultimately depend upon space, time and mass, and each of these is connected with muscular sensations; so that it is the production of like muscular sensations that in the last analysis makes measurements possible. This is equally true of measurements of sensation, and it is owing to the fact that in these muscular feelings the more intense really includes the less intense, that the measurement of sensations of intensity is possible. (A long digression discusses whether sensations of sound-intervals can also be reduced to this category.) If this theory is true, then, Dr. Münsterberg infers, sensation-differences will be perceived as equal when they give rise to the same difference of sensations of muscular tension, and inasmuch as these occur in all senses we should be able to compare sensation-differences amongst disparate senses. This apparently difficult, if not impossible problem, we are assured, is easy when we once set about it, and we are presented with the result of such a series of trials. One black disc was kept constant with 20° of white, while another was changed by 10° changes from 20° to 180°; again the left arm made a constant excursion of 20 cm., while the right arm made an excursion that would seem as different from the excursion of the left arm as the second disc seemed lighter than the first. In the same way, differences of pressure and differences of sound-intensity were compared, or rather translated into differences of arm-motion, and though the separate experiments were conducted in an utterly irregular order, the result is a very orderly rise of the excursion of the right arm with the differences in the lightness of the two discs, or the weight of the two weights, or the loudness of the two sounds. The same three classes of sensations were also translated into differences of visual extension, and with an equally satisfactory and regular result. The results are not considered sufficiently numerous or accurate to warrant attaching importance to the numerical tables (especially as they are founded upon but one subject, Dr. Münsterberg); but they are tested in several ways, and found to give consistent results among themselves. The relative increment of stimulus for the different senses, however, does not seem the same, but the percentage of stimulus-increment necessary to produce equal differences of sensation in the three senses of pressure, hearing and sight, are in the ratio of 2.0, 1.0 and 1.24. This practical result is held to give the theory an unusually high degree of probability, and it is furthermore shown that the theory is capable of harmonizing the contradictory results of different observers in a variety of ways. For example, whether the method of mean gradations will give an arithmetical or a geometrical mean, will depend upon whether we attempt to

place a sensation in between two others which will seem in absolute value equally distant from each of the other two, or whether we attempt to make the differences of sensation, *i. e.*, the differences of the muscular tensions, alike. In the latter case Weber's law will hold. The law, too, will hold, for the same reason, when the direction of the difference of sensation is perceived, but is not so likely to hold when the bare difference, without a perception of the direction of this difference, is tested.

Interesting and original as this theory is, it cannot be accepted without much experimentation by rigid methods and with due reference to other modes of explanation of the results. It is certainly difficult to conceive that the difference between two pressures or two sounds can be equal in any sense to the differences between the lengths of two lines. What seems to have taken place is this: the weakest and the strongest sensation in each sense were known, as also the number of different sensations in between; the smallest sensation was naturally associated with the shortest length, and the movements of the eyes or the arms having their natural limits, these limits stood for the most intense sensations. The results would then simply show that it is possible to keep in mind these ten sensations or differences of sensation in the disparate spheres of sensation, and make the several intervals or magnitudes correspond roughly each to each. That this power is interesting and worthy of study cannot be doubted, but that it can only be explained by the theory of muscular-tension feelings, or proves this theory, is by no means clear. J. J.

Sur la perception des radiations lumineuses par la peau chez les Protées aveugles des grottes de la Carniole, RAPHAEL DUBOIS. Comptes rendus. T. CX, p. 358, 17 Fév., 1890.

The ocular vision of these creatures is so imperfect that they will run against objects set in their way. They nevertheless perceive the difference between light and darkness, (in part by means of a kind of dermal vision most distinctly marked at certain points about the head and tail), and are profoundly disturbed by the former. In the dark they will remain for a long time in one place, but on being stimulated with a beam of light soon make efforts to escape. This characteristic has been used by Dubois to determine what might be called their reaction-times. In 43 experiments the average time was 11 seconds; in 30, in which the eyes were covered with an opaque mixture, there was reaction in about 24 seconds, except in three cases where there was none at all. With colored lights (produced with colored glass) for which the intensity of the illumination decreased in the order, yellow, blue, red, green, violet, and with the eyes open the following times were found: violet 26 seconds, blue 23, red 16, green 13, yellow 10.5. Where the eyes were covered the results with colored lights were conflicting, probably from too frequent repetitions of the tests. The order of preference of the animals was: black, red, yellow, green, violet, blue, white. The same author has studied the visual ability of the molusk *Pholas dactylus*, see *Comptes rendus*. CIX, pp. 233 and 320.

Experimentelle Studien über den Zeitsinn. MICHAEL EJNER. Inaug. Diss. Dorpat. 1889.

The intervals studied by Ejner were very much larger than those used by most previous experimenters, 0.5, 1, 2, 3, and 4 minutes. The method was that of average error and both forms of it were used: single reproductions, for which the standard is given each time, and multiple or serial reproductions where the standard is only given at the beginning of the series. The time was measured with a stop-watch of some kind,